iii. Operation

The mode of operation presented here is based on the assumption that the conditions in RHIC represent the standard of reference for all activities. In a setup procedure, RHIC is made ready for filling and then kept stationary in that state until it is filled. In most filling scenarios, with the exception of the switching magnet, all magnets in the ATR are excited and remain stationary. The ATR is designed to transport particles with rigidities up to 100 T·m. Both gold and proton beams are injected at the same rigidity. For transport of gold ions, the rigidity of the line upstream of the stripping foil must be increased by a factor of 79/77 compared to protons, since the charge state is increased when the foil strips the last two electrons. The ATR has a window of spin transparency for polarized protons at $\gamma = 26.75$ ($p = 25.38$ GeV/c) which is sufficiently above transition in RHIC ($\gamma_T = 22.89$).

When used for filling RHIC the AGS may accelerate trains of from 1 to 4 bunches. When the extraction field is reached, the beam is accelerated until the AGS circumference becomes 4/19-δ of the circumference of the injection orbit in RHIC (4/19 is the ratio between the circumferences of the reference orbits, δ is a small number). When the difference has become small enough, a phase-locking loop between the two rf systems takes over and locks the AGS rf frequency to the RHIC rf frequency. The phase is then shifted so that the bunch that is to be extracted from the AGS arrives in RHIC trailing the previous one by a predetermined number of RHIC buckets.

With its phase now as correct as it can be made to be, the bunch keeps circulating until its transfer to RHIC is initiated by excitation of the extraction and injection kickers. This is triggered by coincidence circuitry that produces a signal only when the last bunches of the bunch trains in each ring pass through specific azimuthal positions simultaneously. The waiting period may last up to 19 revolution periods in the AGS and up to 4 in RHIC, thus up to about 51 μsec, which time represents a `superperiod' in the AGS/RHIC cycle. The excitation of the extraction kicker in the AGS drives its last bunch into the transfer line, without disturbing the remaining ones. The extracted bunch finds the injection kicker in RHIC properly excited when it arrives there and becomes the last bunch of the train circulating in RHIC. The phase relationship between the last bunches in the two rings is now destroyed, since the new last bunch in the AGS is passing one AGS bucket spacing earlier than the previous one, while the next empty bucket in RHIC is passing three or, on day-one, six RHIC bucket spacings later than the previous one. That relationship must be restored before the next transfer can take place. The bunches in the AGS are shifted later in time by one AGS bucket spacing plus the appropriate number of RHIC bucket spacings by manipulation of the AGS rf frequency. This adjustment requires a time interval of the order of 33 msec prior to the next bunch transfer, the recharging times of the kicker power supplies and aperture considerations in the AGS imposing a practical lower limit. A limit on extraction frequency has been set at 30 Hz by hardware considerations. The tolerance on the relative constancy of the guiding fields in the two rings during this process is of the same order as that on the relative synchronous energies, i.e., a few 10^{-5}.

When the AGS has been emptied of its bunches in this manner, it returns for repeated acceleration cycles until all but a few of 56 (later 112) rf buckets in RHIC are filled. The AGS cycle time is about 4 seconds, and 19 cycles of 4 ion bunches each would fill 60 RHIC buckets in one ring. In fact, a gap of about 1 μsec will be left in the circulating beam (omitting 4 of 60 bunches) to facilitate the rise of the RHIC beam dump kicker magnet system.